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Identification of key parameters determining Danish homeowners' willingness and motivation for energy renovations

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Abstract

In Denmark, around Europe and in the rest of the world there is a challenge of motivating homeowners to conduct private energy renovations despite a number of benefits. A particular great energy saving potential is present in the Danish single-family houses erected in 1960–1979, but the potential is not utilized for various reasons. However, survey results show that improvements in comfort, indoor environment and architecture combined with a reasonable project economy can motivate the average homeowner of these buildings. The objective of this paper is to further process the survey data from 883 homeowners and determine if all homeowners can be assumed as one homogeneous group in terms of motivation factors or if significant differences occur, what causes the differences and how does this affect the future motivation strategy.

The conclusion is that the homeowners cannot be assumed as one group, but must be addressed as individuals. The key parameters for determining the motivation factors are related to the homeowner's current position in life: age, presence and age of children, time of ownership, occupation and income. Most likely to be motivated to perform energy renovation is the younger generation of homeowners The older generation is hard to motivate, but results nonetheless show that it is possible with the right instruments.

Keywords: Energy renovation; Homeowners; Motivation survey; Willingness to renovate; Economy

1. Introduction

The European Union has set up targets for the size of the energy consumption and CO_2 emissions in respectively 2020 and 2050 (European Commission, 2011; Official Journal of the European Union, 2012), and all member states are in the coming years facing the huge task of reaching these goals. The 2020 objectives of the European Union are to reduce the energy consumption by 20%, reduce the greenhouse gas emissions by at least 20% compared to 1990 levels and have 20% of the energy consumption covered by renewable energy. By 2050 the goals are to reduce greenhouse gas emissions to 80–95% below 1990 levels (European Commission, 2011; Official Journal of the European Union, 2012). The energy saving potential in the building sector in both Europe and Denmark is very high and particularly in the existing building stock (Tuominen et al., 2012; Wittchen, 2009; Tommerup and Svendsen, 2006). If the building envelope of all existing

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buildings in Denmark erected between 1850 and 1998 are renovated to the level of the 2008 building regulation for new buildings a potential energy saving of 58 TJ/year is calculated (Wittchen, 2009).

The presented survey focuses on the Danish single-family houses erected in the 1960s and 1970s. This is where the highest energy saving potential is found in a housing typology, which is also economically sensible to renovate and where homeowners have a desire to live in the buildings in the future. In the approximately 440.000 buildings in question a potential energy saving of 7811 TJ/year is found purely by renovating the building envelope up to a level comparable to today's building regulations for new buildings (Building regulations 2008) (Wittchen, 2009). Furthermore the area of these buildings is 83 million m^2 thus a significant share of the total Danish building area of 343 million m^2 (Wittchen, 2009). In all single-family houses combined (erected 1850–1998) there is a total energy saving potential of 10,274 TJ/year purely by renewing and renovating the technical installations (Wittchen, 2009). All rational motives for researching how the renovation of these m^2 can be initiated in the best manner are explored.

In the 1960s and 1970s a building boom took place in Denmark and as many houses as those erected in the previous 100 years together were erected over this 20 year period (Lind and Møller, 1996). The industry of standard houses took its starting point and rapidly grew and spread across the country. At this point in Danish history, most people lived either in the city or in the countryside to be close to their work. With the sudden possibility of building a private home outside the city center, but still close enough to work there, and at a reasonable price, many families invested in a standard house and the suburbs developed. In a period of 20 years 440,000, primarily standard, single-family houses were erected and many families moved to the suburbs and the desired green areas. The Danish single-family house typology emerged. The traditional Danish single-family house is a detached house usually in a single plan, surrounded by a private garden and gathered in neighborhoods with similar buildings. The neighborhoods are known and loved for their peace and safety and for the perfect combination of privacy and solidarity among the homeowners in each little closed street (see Figs. 1 and 2).

In 2010 roughly 50% of the Danish population lived in the 1,037,091 occupied single-family houses. Of these houses 439,396 were erected between 1960 and 1979 corresponding to approximately 42% of all present single-family houses in Denmark (Statistics Denmark, BOL22). The building type is the absolute preferred type of accommodation in Denmark and is occupied by all types of family combinations.

These standard houses are due to their age in these years ready for renovation. The insulation level and materials used to build the houses was up-to-date at the time of construction, but is now outdated and the houses are in need of modernization to be futureproofed. The *U*-values of the construction parts (Fig. 3) clearly indicate why homeowners in these buildings are using a high amount of energy to heat up their house and also why many homeowners experience problems with draft and mold.

In order to utilize the energy saving potential energy savings ought to be considered and applied in the coming renovation work both to make the energy savings as cost effective as possible but also since many years will pass before these houses will need renovation again. The standardization of the houses furthermore makes them an obvious typology to start with, since many solutions can be applied to numerous identical houses without big alterations, which presumable can make the work less expensive than costume designed solutions.

> *"The rate of building renovation needs to be increased, as the existing building stock represents the single biggest potential sector for energy savings. Moreover, buildings are crucial to achieving the Union objective of reducing greenhouse gas emissions by 80-95 % by 2050 compared to 1990."*
>
> [Official Journal of the European Union, 2012, p. 3]

To achieve the energy saving objectives put up by the European Union faith cannot only be put in renovating the publicly owned buildings. Since the majority of the dwelling stock in Europe is privately owned (74%) (Tuominen et al., 2012), the private homeowners too need to be motivated to renovate their houses and do so with the additional purpose of achieved considerable energy savings i.e. so called energy renovations. Various barriers have, however, prevented energy renovation of the private building stock. The most substantial barriers are related to economy (uncertainty about the savings, size of investment and lacking economic incentives) along with lacking knowledge and interest in the subject (Tuominen et al., 2012; The Danish knowledge centre for energy savings in buildings, 2009; Jensen, 2004, 2009). A previous study (Mortensen et al., 2014) has, nonetheless, shown that the average Danish homeowners of a single-family house from 1960s to 1970s can be motivated to conduct energy renovations of their homes by improvements in the quality of comfort, indoor environment and architecture. These parameters should, in order to be effective on the average homeowner, be supported by a sensible project economy (investment size vs. energy savings), since the economy is still seen as a deal breaker if not found reasonable by the homeowners.

A Danish study carried out in 1999–2001 (Almlund et al., 2002) examined the owners of single-family houses from the 1960s and 1970s. The objective of the study was to determine; Who are these people and how can they be convinced about the benefits from ecological renovation and maintenance? (Almlund et al., 2002) The project was limited to addressing renovation and maintenance of one room; kitchen, of one building part; windows and of resources flow: water (wastewater/water savings). The conclusion was that the homeowners due to their interest,

Figure 1. Illustration of a typical Danish single-family house neighborhood [www.byggeside.dk].

Figure 2. Illustration of a typical Danish single-family house [www.byggeside.dk].

economy and need for motivation can be divided into three groups; The young families, the middle-aged families and the elderly single-family house owners (Almlund et al., 2002). The three groups have different approaches to renovation and maintenance and therefore the task of convincing them require different means. The young families have most interest in ecological renovation and maintenance, but cannot afford it. The middle-aged families have a good economy and conduct prestige (visual) projects when the children move away. The elderly do nothing about their house, since they don't expect to benefit from it as they will move away within a limited number of years (Almlund et al., 2002). These results clearly indicate that in 2001 the homeowners cannot be assumed as one homogeneous group when it comes to their motivation for renovating the kitchen and windows and saving water.

This paper follows up on the 2001 study (Almlund et al., 2002) and the previous results from the 2012-motivation survey (Mortensen et al., 2014). The objective is 1; to define the possible demographic variables which have an impact on the homeowners' interest, willingness, motivation and preferred consultant and 2: to determine if the three subdivisions of the homeowners defined by Almlund et al. (2002) are also presently occurring when renovation is covering the entire house instead of only three selected areas (kitchen, windows and water). Clear differences are seen between the three separate areas focused on in the 2001 survey by Almlund, Jessen and Elle and an energy renovation of the entire building envelope, which the 2012 study by Mortensen, Heiselberg and Knudstrup are addressing. Firstly, the physical size of the areas affected by the potential renovation and the work required is different and secondly the level of exposure of the results can be varying. Many aspects of a building envelope renovation can be invisible for the homeowner whereas a new kitchen or new windows in most cases will generate a visual result. Furthermore the reasons for renovating/changing a kitchen can be different from the reasons for renovating the building envelope. For instance an out of fashion kitchen can be replaced by a new one even if it is not outworn whereas the building envelope in most cases will only be renovated when a need is present. Moreover, it is expected that the situation in 2001 and the 2012 situation cannot be compared since eleven years have passed and the public awareness toward energy consumption and savings have increased in these years, particularly in relation to the new targets

Building component	U-value (W/m²K)	Potential saving/year (TJ)
External wall	0.65-0.50	2,137
Roof	0.26	2,101
Floor	0.30-0.28	49
Windows	2.52-2.48	3,524

Figure 3. Average *U*-values of the building components and energy saving potential in Danish single-family houses erected in the 1960s and 1970s.

of the European Union and the national government for reducing the energy consumption and the amount of greenhouse gases over the coming years.

This paper presents results from a further and deeper analysis of the data set from the questionnaire survey by Mortensen, Heiselberg and Knudstrup and examines whether all homeowners in 2012 can be assumed as one homogeneous group (the average homeowner) or if there are significant differences between the various homeowner groups, which need special attention and following adapted motivation strategies. The data set has been analyzed according to eight demographic variables of the respondents (gender, age, household composition, place of residence, time of ownership, education, occupation and income) to highlight possible differences caused by either of the variables. Four areas are examined to search for potential variations; interest in energy renovation, willingness to renovate, motivating factors and finally preferred consultant. This is to provide a more detailed and full picture of the respondent group, which in the first take (Mortensen et al., 2014) was viewed as one group representing the average homeowners. The results presented are based on data from a questionnaire survey carried out in January 2012 where 4000 single-family house owners across Denmark were invited to participate, and 883 completed a questionnaire. The questionnaire revolve around the following themes; energy consumption, architecture, comfort, indoor environment and investments for renovation. First part of the paper shortly describes the choice and design of the method and approach. The second part concentrates on the parameters, which affect the homeowners' level of interest in, willingness to and motivation for energy renovations and their preferred consultant(s). Following is a discussion about the results and how these can utilized and implemented in the future to motivate private homeowners and increase the number of private energy renovations, and finally a conclusion enhancing the key results is given.

1.1. State of the art

Around Europe many countries are fighting the somehow same barriers for energy renovation as experienced in Denmark (primarily economic uncertainty, lack of interest and knowledge) and different actions have been taken to initiate the progress of more renovations and the motivation of private persons. Germany, Austria and Switzerland are well advanced compared to Denmark since they have provided homeowners with different options not present in Denmark. Most of the options are related to different economic aspects of the renovation projects.

In Switzerland some of the significant barriers are market imperfections, information asymmetries, high investment costs, uncertainties about the benefits and future energy prices (Amstalden et al., 2006). To determine the most beneficial political initiatives to introduce in the future, the potential effect of combinations of various parameters (political regulations, subsidies, fuel prices, tax deduction and carbon taxes) have been calculated. In this way political initiatives can be motivating for different levels of energy renovation and affect when a renovation is economically profitable by offering a certain beneficial subsidies and increased taxes on energy use. The politicians therefore have the ability to break down the barriers regarding investment costs (by offering subsidies) and uncertainties about the benefits and future energy prices (by introducing a carbon tax, that make the saving economically worthwhile even with low energy prices) and through these initiatives increase the motivation for energy renovations (Amstalden et al., 2006).

In Upper Austria various parameters have also been brought into play simultaneously. Better financial loans for energy renovations and energy efficient new buildings than for non-energy efficient building work are provided. This has motivated many to build passive houses and renovate to a deeper level than seen previously. Furthermore is consultation meetings offered to both homeowners and business owners in order to make them feel secure about the future projects. Professionals are likewise taken into consideration in the strategy. They can undergo further training in energy renovation, learn about the potential energy savings found and get instructions in how to perform the job (Egger and Öhlinger). A combination of these offers have proven successful in Upper Austria, where the renovation rate is higher than in the remaining Austria, since barriers of several user groups this way can be broken down simultaneously.

The German state too offers subsidies and beneficial loans to renovation projects beyond the minimum standard. There is moreover a very strict building code to comply with, to get the favorable loans, since the same standards are applied to renovation projects as for new buildings or even 30% lower to get the lowest interest rate. This approach is taken to motivate the building owners to deep renovations instead of low level renovations. Opponents claim this to be a non-efficient economic policy since the first saved kW hs are much cheaper than when approaching passive house standard (3 eurocent/kW h vs. 40 eurocent/kW h) (Galvin, 2010). Still it cannot be predicted how it would affect the homeowners will and motivation if the same subsidies were granted for renovations of lower standards and requirements dropped. Germany is said to be in front when it comes to saving energy in the building sector and with the purpose of ensuring deep renovations the current way has an evident economical advantage for the homeowners and motivate them to be ambitious.

In all three cases, the success is a result of more actions taken simultaneously, designed in order to support each other, and based on the desire the break down the most crucial barriers.

Other studies are focusing on the user groups and the potential differences within. A Finish study (Moula et al., 2013) has examined the social acceptability of renewable

energy technologies (RET) since a lack of social acceptance might be a barrier for the implementation of RET. A questionnaire survey with 50 respondents was carried out to define the level of acceptance and understanding of RET in Finland. Within the survey it was among others investigated if age, gender, class and income affect the results or if all the respondents have the same acceptance, knowledge and understanding of RET. The results showed that the respondents are not alike and that both age and income influence the level of acceptance.

> *"In contrast to many earlier studies, in this survey we found that the level of support for renewable energy technology toward better environment seems to correlate with age, with older people being more supportive than others."* [Moula et al., 2013]

The younger respondents had a higher awareness and apprehensiveness toward RET and the environment than the older. The income level of the respondents was found to be connected to the level of acceptance of RET and have a positive effect on this. The higher the income the higher the acceptance. These results show that in the case of renewable energy technologies and environmental aspects the respondents are not alike, but can instead have different opinions depending on demographic parameters – in this case age and income.

A Swedish study by Nair et al. (2010)) investigated which parameters affect the homeowners decision about energy efficient investments in their private homes, which investments are made and why. The data analyzed contained data from 3.000 homeowners of detached houses. It was discovered that both contextual and personal factors affected the homeowner's reasons and decisions. The personal factors studied were; Education, Income, Age, Gender, Skill, Awareness about energy efficiency measures and Attitude to reduce energy use. The Contextual factors were; Building age, Thermal comfort, Perceived energy cost, Past investment and Location. For the contextual factors especially the building age and the experienced thermal comfort were decisive for the homeowners' choices. The older the building and the lower assessment of the thermal comfort the more likely were the homeowners to invest in energy efficient solutions. For the personal factors education, age, income proved to have the largest influence. The remaining four parameters had little or no effect on the decision and the reasons for a given decision.

In a study made in China the indoor temperature in households was measured during wintertime in areas with hot summers and cold winters (Lin et al., 2016). The objective of the survey was to determine the homeowners' heating behavior during the heating season. The researchers have collated the temperatures with the heat consumption and these results have been analyzed to define drivers for the use of heating. It was clear to the researchers that the average indoor temperature was not comfortable for the occupants at around only 13.5 °C, since a very limited timeframe for the heating operation is present. The heating is activated according to both the time of day and the outdoor temperature. What the researcher moreover found was that a number of additional factors influence the occupants heating behavior. These factors are; household income, presence of children, the heating system in the building and the occupants' thermal experience, which also differs from person to person. This study is, as the Swedish study, an example of the building (contextual factors) and the personal factors being equally important to define the human actions.

The results from the three studies about the user groups signify that we cannot expect the homeowners to act alike if their decisions are not based on the same contextual and personal factors. We need to look at both the building and the humans inside as well. What a rational conclusion is to one homeowner is not necessary a rational decision to another if they do not have the same point of departure. The important aspect is to determine the influential factors (contextual or personal) and their effect in each situation. The personal factor such as for instance gender might affect a person's decision in one situation whereas the same factor will have no influence in another situation. In the study presented in this paper the aspect of defining the factors and their effect is related to Danish single-family house owners and their motivation to energy renovate their private house.

2. Description of method used

There are different methods to use for social research, and the main two are quantitative and qualitative methods, which both contain various approaches (Bryman, 2008). The two methods each have forces and limitations, which depending on the survey objective can create the base for the choice of method. This survey was carried out by the use of a quantitative method. Since the objective was to generalize over a large amount of homeowners (approximately 440.000 households) and provide results which are to be useful for developing motivation strategies for these homeowners a high number of participating respondents given comparative answers was found more beneficial than fewer in-depth details, which is often the case when a qualitative method is used. Also, the benefits from a quantitative method and a questionnaire, which was the approach of this survey, are moreover that the respondents can easily be spread across the country as no personal interaction is needed and the respondents can answer the questions whenever time is available. In addition, more respondents are able to participate within the same timeframe since the questions are predesigned and unchangeable, the process is very structured, and, hence, data processing is relatively easy to conduct (Bryman, 2008). The anonymity of the respondents is likewise a benefit from the questionnaire since it is trusted that the respondents are more likely to answer truthfully (and not what is expected from them) when not faced with an interviewer. For the objective of

the survey of defining among others the interest level and motivation factors, it is crucial that the respondent answers honestly and is not influenced by a researcher's presence and the natural will to act as a perfect energy conscious homeowner, if he in fact is not. The anonymity is not a guarantee for truthful answers, but it can reduce the risk of interviewer effect. The quantitative methods and questionnaire approach have some weaknesses which the qualitative methods and for example an interview would not have. By interviewing the respondents in person it would be possible to correct misunderstandings in the questions and ask supplementary questions if needed. Furthermore would the personal contact with the interviewee give the researcher knowledge about the context in which the questions have been answered, which in some cases can provide explanatory information about the given answers (Bryman, 2008). Despite these limitations, and often a longer reply time, the questionnaire approach is chosen for the survey since it is found to be most advantageous with the objective in mind.

2.1. Design of questionnaire

The questionnaire was designed purely for homeowners since they are the ones to motivate and therefore it was found natural purely to focus on and ask them about their opinion and experiences with the subject. A former literature study about the barriers for private energy renovations in Denmark (Mortensen et al., 2011) was the basis for the questionnaire development along with the researchers' hypothesis about what can generate motivation for homeowners. Hence, the questions revolve around topics defined as barriers for private energy renovations; knowledge about and interest in energy renovations, problems and potential improvement of comfort, indoor environment and architecture and finally uncertainty about the project economy. These topics need to be investigated further to generate a deeper understanding of the current situation and to define potential tools to change the situation. The questions are developed to non-specialists and kept in an informal and none technical tone to avoid misunderstandings and respondents feeling looked down at since that might prevent them from answering the questions. This approach include that nowhere in the questionnaire are any specific numbers mentioned or inquired from the respondents. In each of the themes, the necessary output is the homeowners' view on the aspects. Actual and accurate measurements of for instance the indoor environment is the not the objective of this survey. The problems and potential in the buildings are well documented, but the homeowner does not act on this information (Wittchen, 2009; Tommerup and Svendsen, 2006) why his interpretations, feelings and desires are more valuable in the search for efficient motivation strategies. The questionnaire consists of five themes to make it more comprehensible for the homeowners. The five themes are as follows: (1) general information about the respondents, (2) energy consumption and renovation, (3) architecture, (4) comfort and indoor environment, and (5) economy.

"1. General information" is about the homeowner and demographic parameters such as age, gender, education, and income "2. Energy consumption and renovation" are focusing on the homeowners interest in and evaluation of his current energy consumption and his will to, interest in, reasons for and reservations toward performing an energy renovation. Furthermore is he asked to rate different parameters such as energy consumption, functionality, maintenance level and monthly expenses according to their importance and finally he must tell if any renovation or refurbishment work has been performed at his house within the past five years. "3. Architecture" is divided into two parts. First part is a purely visual assessment of different fictitious renovation suggestions. Second part consists of questions related to the homeowner's view on the importance of architecture, the architectural level of his house and the homeowner's wishes for changes. "4. Comfort and indoor environment" include questions about how respectively good comfort and indoor environment are defined by the homeowner. Here the respondent is asked to point out the most important parameters from a list. For comfort the parameters were for instance; "The ability to open the windows", "A stable temperature", "No noise from outside", "Lay-out suits my needs", "I don't feel exposed due to large windows", etc. In addition to this are questions about the homeowner's evaluation of the comfort and indoor environment in the house today and if any problems are present. Finally the homeowner's behavior and the following comfort and indoor environmental consequences are examined. In "5. Economy" the homeowner's knowledge about and use of the potential subsidies to energy renovations are investigated along with his financial reservations in relation to investment in energy renovations. In the last part of the questionnaire the homeowner must evaluate the price of five fictitious renovations

Figure 4. The four areas in which the questionnaire has been distributed with 1000 examples in each region. Aalborg, Aarhus, Odense and Copenhagen (top left, down right).

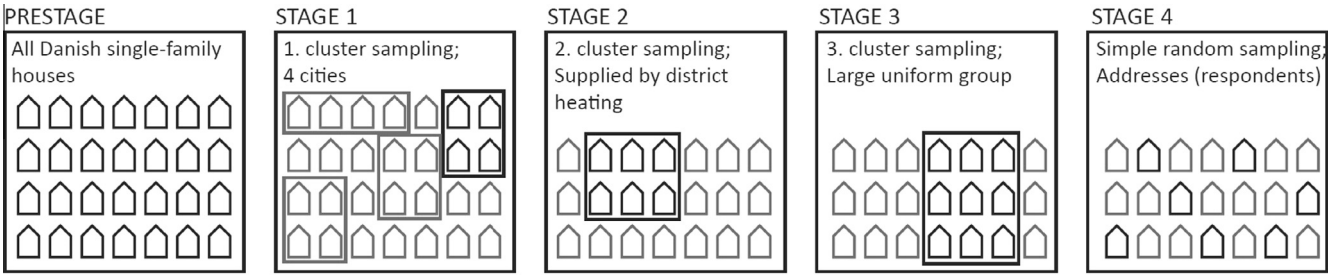

Figure 5. The stages of the sampling of the homeowners for the survey. In each stage, the highlighted box is representing a sample. This sample is the base (the outer box) for the next step in the sampling process.

versus the potential improvements in energy consumption, comfort, indoor environment and architecture.

The target group of the survey is Danish homeowners in the single-family houses erected between 1960 and 1979 and, therefore, the questionnaires were distributed across Denmark, with 1000 sent out in suburbs of respectively Aalborg, Aarhus, Odense and Copenhagen (Fig. 4). These four cities are the four largest cities in Denmark and are chosen for the survey due to their size (number of inhabitants) and geographic spread across the country. It is trusted that the respondent group because of the geographic spread of cities and the sampling method (multi-stage cluster sampling including a simple random sampling (Bryman, 2008)) in principle is representative for Danish single-family homeowners.

All respondents were selected by multi-stage cluster sampling including a simple random sampling (Bryman, 2008) (Fig. 5) by the use of information from four district heating companies in respectively Aalborg, Aarhus, Odense and Copenhagen. The prestage group consists of the full target group: All Danish single-family houses erected between 1960 and 1979 (approximately 440.000 units). The first sampling gave four clusters (Aalborg, Aarhus, Odense and Copenhagen) defined within the target group of all Danish single-family house homeowners. Second sampling provided one cluster, those houses connected to the district heating grid, in each of the four previous clusters. Third sampling defined one or more clusters of a certain size in each of the four clusters by information from the respective district heating companies about large groups of homogeneous buildings. Fourth sampling was a simple random sampling where addresses (respondents) were randomly selected until 1.000 addresses were selected in each of the four clusters. The respondents' names were found by the use of the webpage www.ois.dk,[1] where each house was also checked for the year of construction to ensure that the house was erected in the right time period to match the target group. For each of the addresses the first listed owner was the one to receive the questionnaire regardless of gender.

[1] www.ois.dk (Public information server) is a national database with data about buildings such as area, construction year and name(s) of owner (s) and is administrated by the Ministry of Housing, Urban and Rural Affairs.

An accompanying letter promised the homeowners anonymity and informed them about the survey objective, the authors and how to complete the questionnaire on either paper or online (optional).

2.2. Questionnaire validation

Content validity: The researchers conducted the content validity test and checked if all important aspects of the theme were covered based on the research questions to be answered and the following hypothesis. In this process unnecessary questions and response options were removed and if needed further questions and/or response options were added.

Face validity: The questionnaire was pilot tested by 12 homeowners before launching it. The 12 homeowners were within the target group, but not part of the selected respondent group, representing different age groups and all without prior knowledge about the project and the questionnaire. They were supplied with the same questionnaire and accompanying letter as the potential respondents later received. The test panel received the letter and questionnaire without further instructions than given in these and were asked to write down all questions, confusions or problems they might have during the completion of the questionnaire on either paper or the online versions. They were asked to determine if the questions were clear, understandable and in a logical order and furthermore to give comments on the content in general. After this the researchers reviewed the comments with the members of the test panel individually. A group of four consultants from the industry were moreover asked to review the questionnaire to determine if the questions make sense and can be useful in the future. The questionnaire and letter were refined and modified based on the feedback from the test panel and the industry group.

3. Survey representativeness

3.1. Respondents and statistical data

There are statistical differences between the respondent group (consisting of the 883 homeowners who completed the questionnaire) and the statistical basis for comparison; the group of Danish single-family homeowner living in a

house erected 1960–1979. The respondents were asked to give their gender, age, household composition (children in the house or not and age of these), place of residence, time of ownership, education, occupation and income to gather information about the respondent group. This information was compared to statistical material were this were available. Three areas were compared to the statistical data for Danish single-family houses erected 1960–1979; gender, age and place of residence. The remaining aspects are not compared due to a lack of available statistical data.

In the respondents group there was a higher percentage of men (Fig. 6) and homeowners older than 50 years (Fig. 7) than what Statistics Denmark state to be the case in Denmark (Statistics Denmark, BOL201). A reason for the high ratio of men in the respondent groups can be that the questionnaires were distributed to the owners of the house and in Denmark traditionally the man owned the house. A majority of the questionnaires can for this reason have been sent to men and an overweight of men replying will be a natural consequence of this. The letters were distributed to homeowners and the data from Statistics Denmark tell of the distribution of gender in the households and not the distribution of gender among homeowners, this is assumed to be a reasonable conclusion for the difference among genders. 59% of the respondents have lived in their house for more than 20 years, which is also expected to differ from the statistics, however information to verify this is not available.

In this paper the results from the questionnaire survey are examined by dividing the replies after eight different demographic parameters. One of these parameters is gender, and any present differences between the two genders will be made visible throughout the paper. The same will be the case with the age of the respondents and with the time in which they have lived in their house.

The geographical range of the respondents is evenly distributed presumably since the questionnaire was sent to an equal amount of people in each region. Odense; 27% of the respondents, Copenhagen; 26% of the respondents, Aarhus; 25% of the respondents and Aalborg; 23 % of the respondents. The statistical range of single-family houses in each of the regions is a little different from the spread of the respondents. Copenhagen and surroundings have 32% of all single-family houses in the four regions, Aarhus

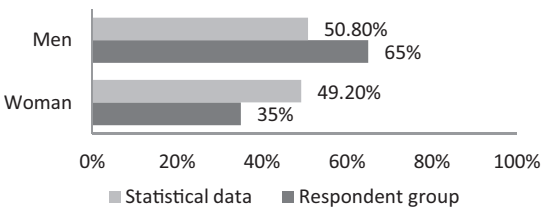

Figure 6. Distribution of gender in the respondents group compared to statistical data from Statistics Denmark of the 2012 distribution in Danish single-family houses erected between 1960 and 1979, for persons older than 18 years of age (Statistics Denmark, BOL201).

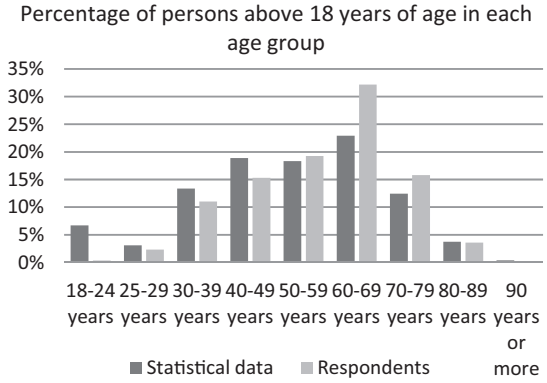

Figure 7. Age distribution of the respondents compared to statistical data from Statistics Denmark of the 2012 age distribution of residents in Danish single-family houses erected between 1960 and 1979 (Statistics Denmark, BOL201).

has 25%, Aalborg has 24% and Odense has 19% (Statistics Denmark, BOL22). Since the respondents are equally dispersed, the results are seen as being valid for all four regions and give an average picture of the Danish homeowner which can be equally truthful in each region.

3.2. Survey reply rate and statistical uncertainty

For the survey 4000 Danish homeowners were sent a questionnaire. The 4000 homeowners were selected by a number of cluster samplings followed by one simple random selection (Bryman, 2008) (Fig. 5). Of the 4000 invited homeowners 883 replied, giving a reply rate of 22%. With the typical used confidence level at 95%, a population of 440,000 (the approximate number of Danish single-family houses erected between 1960 and 1979) and 883 responses result in a confidence interval at 3.3% given by a random check calculator (Rambøll). The certainty of the total survey is, therefore, between 91.7% and 98.3%, which is found to be reasonable for the results to be applicable and trustworthy. Furthermore the number of replies given is higher than any other survey about the topic and with the homeowners as respondents, the results are valuable for further development in the area.

3.3. Survey representativity

There are differences in the numbers from the respondents compared to the statistics (Figs. 6 and 7). However the objective of the paper is to define differences between different homeowner groups and hence it is found that the differences will not have a negative effect on the results. There are respondents in each subcategory of the eight demographic aspects and, therefore, the survey provides an indication of which parameters affect the homeowners' willingness, interests, motivation factors and preferred consultant. As a result, the survey can contribute with valuable information to the existing knowledge about how the number of private energy renovations can be increased. It is

crucial to say that the results presented in the paper are not representative for all Danish homeowners, but only for the ones living in single-family houses erected between 1960 and 1979. No other homeowner groups have been part of the survey, since the focus purely has been on the buildings from the 1960s and 1970s due to the large energy saving potential found here and the age of these buildings.

In some of the divisions, for example when the respondents are divided by their current occupation (Fig. 8), some of the groups contain a low percentage of the respondents and, therefore, the results from those subcategories will not have the same credibility as other divisions. The groups (subcategories) containing less than 5% or 44 persons of the total respondent group are as follows: 0–1 year of ownership (25 respondents), High school education as the last education (27 respondents), Enrolled in education (8 respondents), Unskilled worker (18 respondents), Semi-skilled worker (11 respondents), Receiver of unemployment benefit (20 respondents) and Other occupation (16 respondents). These groups contain too few respondents for the results to be definitive. The results are however included in the paper to provide the full picture of the respondent group. In the following text and illustrations, these homeowner groups will easily be identified marked with (<5%) to illustrate that that group consists of less than 5% of the respondents. Therefore, these results are not definitive, but can however indicate a trend within the specific homeowner group.

4. Parameters determine the homeowners' interest, willingness, motivation and preferred consultant

In this chapter, results from the questionnaire survey will be presented to answer the four questions raised in the following paragraphs. The categories from which the results have been analyzed are related to the eight demographic parameters; gender, age, household composition, place of residence, time of ownership, education, occupation and household income. The presented results show where certain groups of homeowners separate themselves significantly from the average respondent and where the differences between the subgroups within a demographic parameter are significant. The results are presented only if one or more of the subgroups (e.g. homeowners from Aarhus) in a division (e.g. place of residence) separate themselves from the other groups or the average homeowner (Mortensen et al., 2014). If all groups in a division are close to average, the division results are not presented.

4.1. Which parameters determine the homeowners' level of interest in energy renovations and who have the highest interest?

The results clearly show that the younger the homeowners are, the more interested they are in energy renovations (Fig. 9). 41% and 40% of the youngest groups of homeowners (up to 50 years of age) respectively have stated that they have great interest in energy renovation of their house in order to save energy. The average for all the respondents is 33% who have great interest, 60% who have medium interest and 7% who have no interest in energy renovation (Mortensen et al., 2014). For each increase in the age group, the percentage of homeowners who have great interest in energy renovation declines, hence the younger the homeowner the more interest in energy renovation.

The homeowners who have children under the age of 18 years living in the house are more interested in energy renovations than homeowners with no children or where the children have moved out of the house (Fig. 10). Especially families with children between 9 and 13 years have great interest in energy renovations. As many as 46% of this group define their interest as being great. The number is 39% and 38% respectively for groups with children between 0 and 8 years and 14–18 years. For the homeowners who do not have children under the age of 18 in the house, the interest is lowest. If the respondents have children in the two or three different age groups, they are represented in two or three groups.

The time in which the homeowners have lived in their house as well affects their interest in energy renovation (Fig. 11). The results show the tendency that the shorter period in their house, the more interest the homeowners

Question: What is your occupation?		
Reply option	**Number of respondents**	**Percentages**
Enrolled in education <5%	8	1%
Unskilled worker <5%	18	2%
Semi-skilled worker <5%	11	1%
Skilled worker	71	8%
Salaried employee	212	24%
Academic	126	14%
Self-employed	44	5%
Receive unemployment benefit <5%	20	2%
Pensioner	365	42%
Other <5%	16	2%

Figure 8. Example of a demographic parameter where less than 5% of the respondent group is represented in a subcategory.

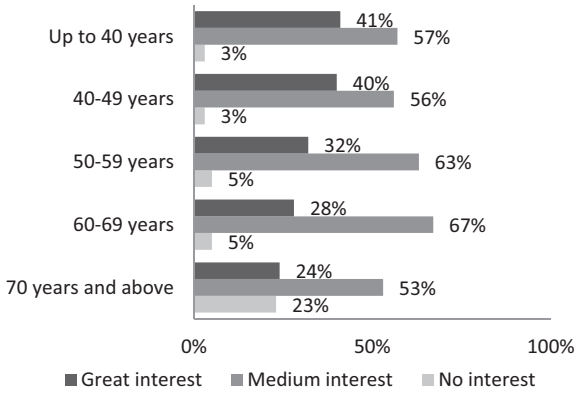

Figure 9. Stated interest in energy renovations according to age.

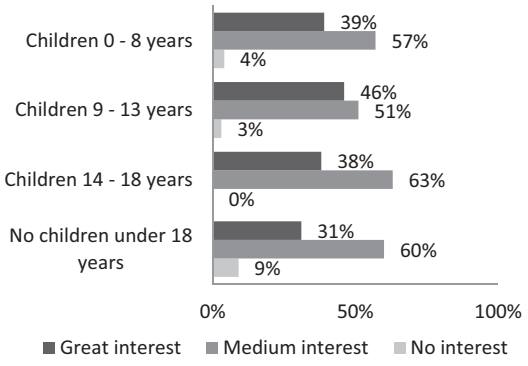

Figure 10. Interest in energy renovations according to the age of children in the household.

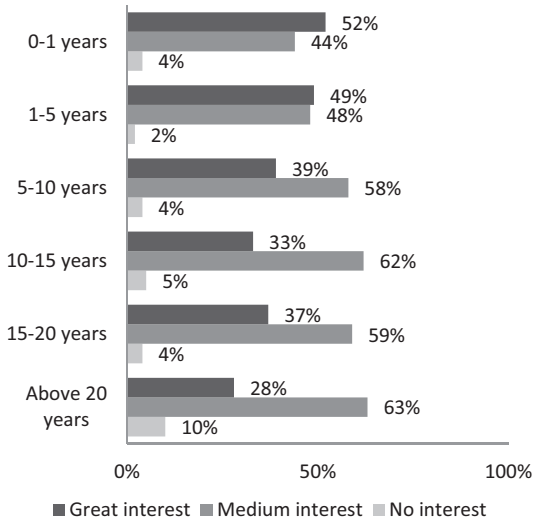

Figure 11. Interest in energy renovations according to the time the respondents have lived in their house.

have in energy renovations. Homeowners who have lived in their house for 15–20 years are, however, more interested than the ones who have lived in their house for 10–15 years.

Furthermore, the data indicate that more homeowners from the Copenhagen area have greater interest in renovations (40%) than the homeowners from Odense (33%), Aalborg (33%) and Aarhus (28%). This points to, that the interest level is also influenced by the area of residence.

The results show that the educational backgrounds too influence the interest, but not significantly (Fig. 12). The homeowners with a craftsman education have a higher level of great interest than all other. 36% of these homeowners have stated that they have great interest in energy renovations while all other groups have an average or lower interest. The homeowners with a high school education (<5%) have the lowest level of great interest: 22%. Here, it is key to remember that this group contains less than 5% of the respondents and the results therefore are only indications.

The division according to the homeowners' occupation displays large differences in the interest in energy renovations (Fig. 13). For the homeowners who are currently under education (<5%), skilled workers or occupied by other jobs than mentioned in the questionnaire (<5%), the percentages of highly interested are as high as 50%, 49% and 63% respectively.

When it comes to the income of the homeowners, only the ones with a yearly household income of 750,000–999,999 DKK (before tax) have significantly higher percentages of great interest (38%) in energy renovations than the average respondent (33%). The remaining groups have an average or below average interest. Only 29% of the group with a yearly household income of 1,000,000 DKK or above have great interest and is the group with the lowest interest. The size of the yearly household income is thus important for the level of interest in energy renovation, but there is not a clear connection between the income level increasing and the interest either increasing or decreasing.

The interest in energy renovations are thus affected by a number of parameters; age of the homeowners, the presence and age of children, time of ownership, occupation and income. The place of residence and education of the homeowners have little influence but not a clear significant effect.

4.2. Which parameters influence the homeowners' willingness to conduct energy renovations and who have the highest level of will?

The interest is not affected by the gender of the respondents, but when focus instead is on the willingness to perform energy renovations the picture changes. The respondents were asked which statements best described their current situation. The percentages of women were highest for six out of seven possible statements about wanting to conduct renovations (Fig. 14) hence they have more will to do so than the men regardless of the incentive. More men (21%) would nevertheless renovate their house to get an improved comfort than the case is with women (19%). The difference is though not unambiguous.

The willingness to renovate has a lot to do with the age of the homeowners (Fig. 15). The willingness drops pro-

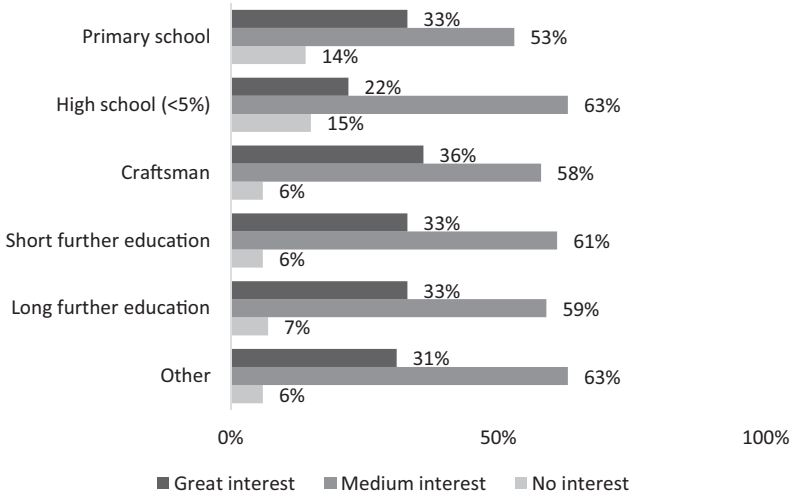

Figure 12. The effect of the educational background on the interest in energy renovation.

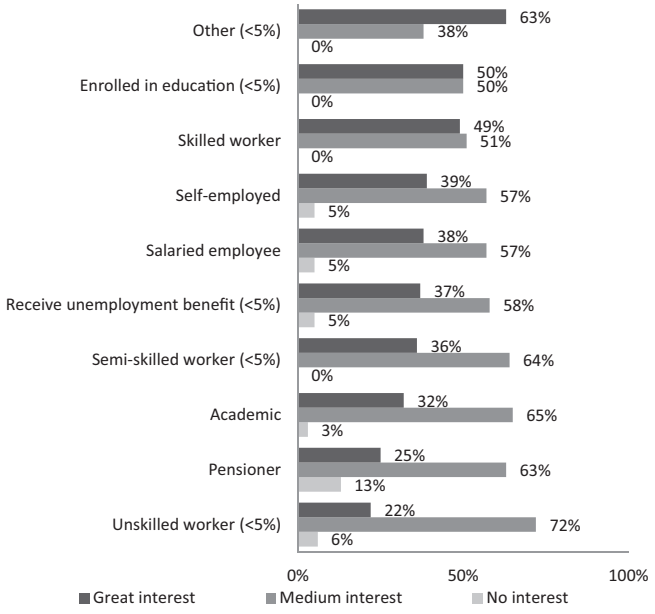

Figure 13. The homeowners' interest in energy renovation when divided by occupation.

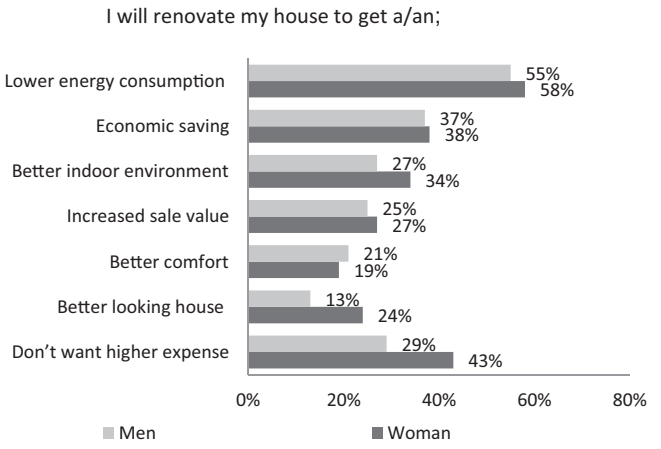

Figure 14. The difference between men and women when asked which statement(s) best describes their situation.

gressively as the age goes up. Until the age of 50 years the homeowners are willing to perform renovations for various reasons. In certain cases some of the homeowners in the age group of 50–59 years state that they want to renovate. After the age of 50 years, or in some cases 60 years, there is not much will found among the homeowners no matter the reason.

Whether children are part of the household or not has great influence on the willingness and reasons for renovation (Fig. 16). The homeowner group with no children under the age of 18 years has the lowest willingness to renovate in all seven listed cases. In particular when the reason for the renovation is improved energy consumption, indoor environment and the look of the house the homeowners with children find themselves in a situation, where they are more willing to renovate their home than the homeowners without children are.

The time in which the homeowners have lived in their house and the willingness to renovate it appear to be interlinked (Fig. 17). The longer one has stayed in the house, the less drive he or she has to renovate it. The decrease in willingness following the length of occupation is not completely clear-cut in all motives, but the tendency is clear to see.

The results indicate that the educational background of the homeowner has limited influence on the willingness to perform energy renovations (Fig. 18). The homeowners with a high school (<5%) or short further education have the highest willingness to conduct energy renovations. The percentage-wise difference varies for each of the statements, but the two groups have, however small, an overall higher willingness to perform energy renovations.

When looking at the correlation between income and willingness to renovate, the five income groups generally

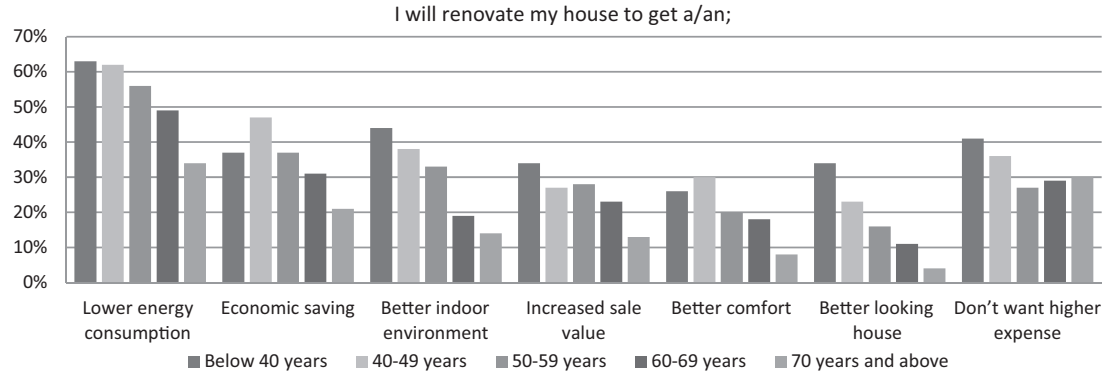

Figure 15. The willingness and reasons for conducting renovation divided according to the age of the respondents.

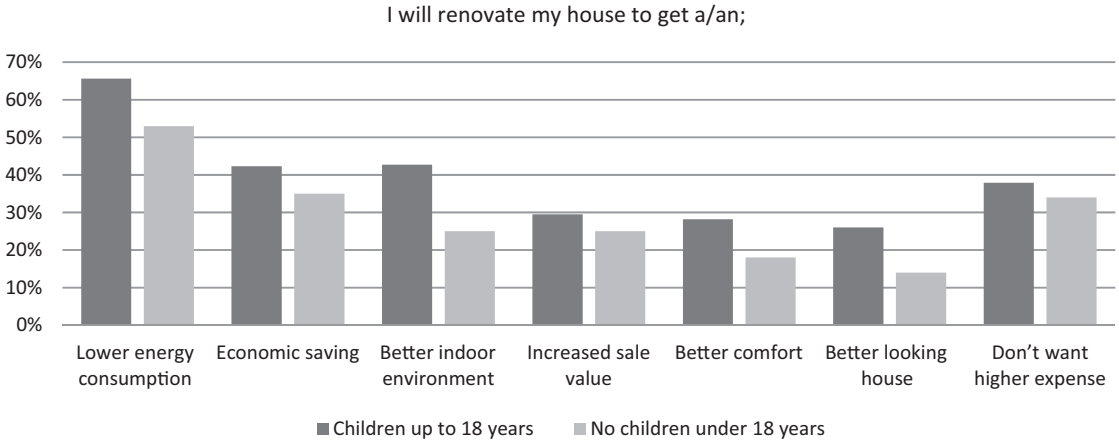

Figure 16. How the willingness and reasons for conducting energy renovation are affected by whether children up to the age of 18 years are living in the house or not.

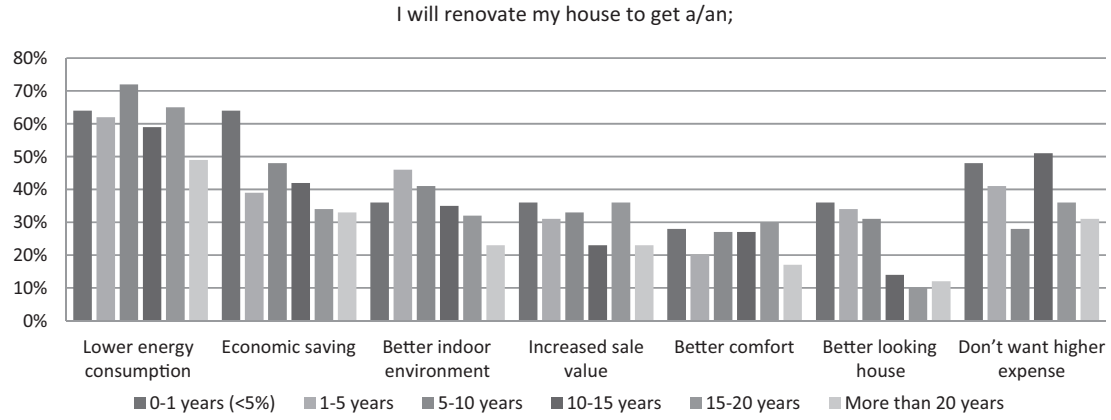

Figure 17. The time the homeowner have lived in his house and how this affect his willingness and reasons for renovation.

speaking can be split into three groups. The first group is the homeowners with a yearly income before tax of 750,000–999,999 DKK who have the highest willingness to renovate. The second group is homeowners with an income of 500,000–749,999 DKK and those with an income higher than 1,000,000 DKK. These homeowners have the second highest willingness. The last group is the homeowners with an yearly income below 500,000 DKK who have the lowest willingness (Fig. 19).

The place of residence does not have a significant influence on the willingness to renovate. The homeowners from the four different areas (Aalborg, Aarhus, Odense and Copenhagen) have different reasons for wanting to renovate, but there is no city from which the homeowners can

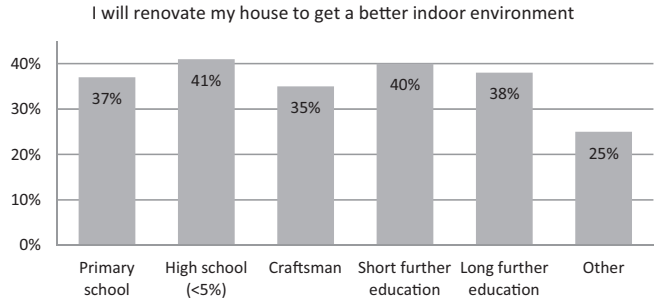

Figure 18. Example of the interlink between educational background and willingness to renovate.

be said to have a higher willingness to renovate than others have.

The will and reason for performing energy renovations varies significantly within the respondent group. The gender and the age of the homeowner, the present of children, the time of ownership and the household income all affect the results. In particular, in the different age groups the diversity is evident.

4.3. Which parameters determine the impact of the five motivation factors?

The interest in and willingness to perform energy renovations and the incentives are, as seen previously, influenced by different demographic parameters. Despite the fact that the willingness and interest to some extent are present among the homeowners, the amount of private energy renovations needs to be increased in order to reach the 2020 and 2050 energy saving goals (European Commission, 2011; Official Journal of the European Union, 2012). But how can the different homeowners be motivated to conduct an energy renovation on their own house? Previous studies (Mortensen et al., 2014) of the motivation factors of the average homeowner showed motivation to be improvements in architecture, indoor environment, comfort and energy consumption following an energy renovation. Looking further into the data, there are differences between which of these parameters are most motivating for the different homeowner groups. The following tables show how the motivation factors on the basis of the results, are expected to affect the different groups compared to the average homeowners motivation level (Mortensen et al., 2014). The conclusions are based on analysis of a number of different questions in the questionnaire (Fig. 20). The questions studied here revolve around the current state of the homeowner's house evaluated by himself (energy consumption, indoor environment, comfort and architecture), possible problems experienced, his behavior in the house, his motives for potential renovating and his wishes for alterations and improvements in his house along with the knowledge about his interest and will to renovate. Analysis of the bivariate correlations are made using cross-tables, where each of the eight demographic parameters are crossed with each relevant question. Meaning that correlations between a demographic parameter, for instance gender (women vs. men) and a question, for example the importance of a good comfort, are investigated. In the data study multiple replies were combined and analyzed to define the areas where the homeowner is most likely to find motivation. Simplified this means that if a person is satisfied with the look of his home, he is not expected to be motivated by improved architecture. If on the other hand, he is cold when at home, he evaluates his current comfort level as bad and he thinks that his energy consumption is disproportionately high, he can be motivated by initiatives that improve these aspects, for instance reinsulating of the façade or a window replacement.

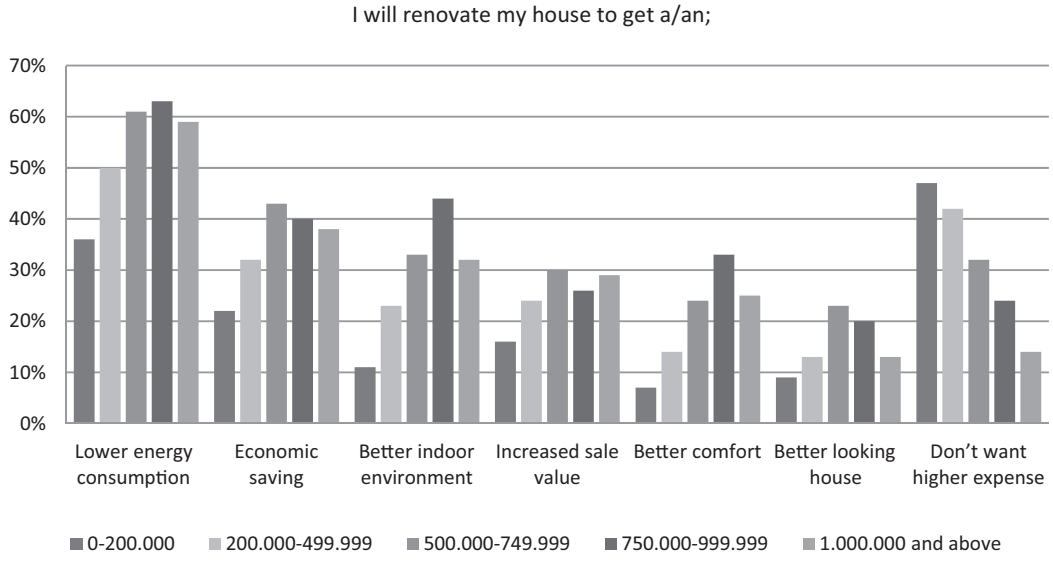

Figure 19. The yearly household income in DKK before tax and how this affects the willingness to and reasons for performing energy renovations.

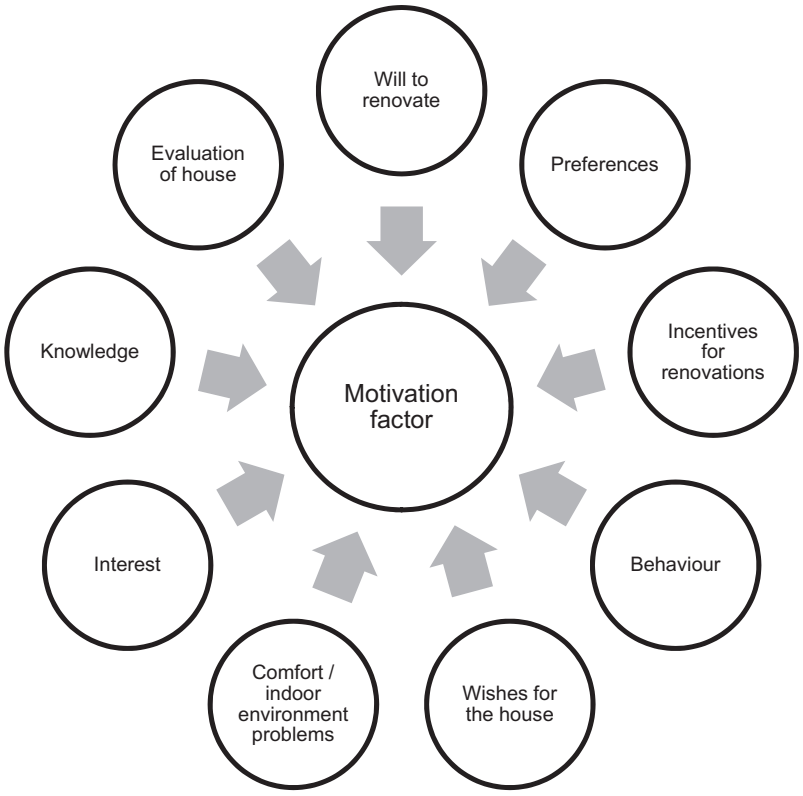

Figure 20. Illustration of the aspects included in the analysis to determine the motivation factors for each demographic group and the level of effect.

When dividing the homeowners after gender, the differences appear. The results indicate that women are more likely to be motivated to perform energy renovations if the result includes improvements in the architectural expression of the house (Fig. 21). When looking at the lay-out, the energy consumption, the indoor environment and the comfort of the house, the two genders agree on the importance, the evaluation and the wishes, and they can both be average motivated by these parameters.

The following tables show the parameters expected to motivate the different user groups. In the following tables (+) and the dark color indicates that the motivation parameter is more than average motivating for the group, A and medium color indicate that the parameter is average motivating for the group and (−) and light color indicates that the parameter is less than average motivating for the specific group. Average is defined as the average numbers for each of the motivation parameters (Mortensen et al., 2014) ±5%.

	Men	Women
I will renovate to get a better looking house	13%	24%
I want to change the appearance of my house	51%	64%
Evaluation of the look of my house: I would like to change 1-3 things	54%	69%
I will perform an energy renovation if it improves the appearance of my house	64%	72%

Figure 21. The differences between how men and women in the respondent groups have answered questions about indoor environment and architecture.

	Up till 40 years	40-49 years	50-59 years	60-69 years	70 years and more
Architectural appearance	+	+	+	-	-
Lay-out	+	+	-	-	A
Comfort	+	+	-	A	-
Indoor environment	+	+	-	-	-
Energy consumption	+	+	A	-	-

Figure 22. Scheme of how the parameters are expected to motivate the different age groups.

As seen earlier, the age of the homeowners has a great influence on their willingness (Fig. 9) and interest (Fig. 15), and the same is the case when it comes to their potential motivation factors (Fig. 22). All five potential motivation parameters are more than average motivating for the young generation whereas the older generation is harder to motivate. The homeowners above 60 years of

age have, despite little interest and lacking willingness, one parameter which is average motivating for them; Improvements in comfort for the 60–69 years old homeowners and improvements of lay-out for the homeowners above the age of 70 years. The remaining parameters are less than average motivating for this group of homeowners.

The same picture is present when the homeowners are divided by the age of the children in the households. Here, the homeowners with children can be motivated more than average by all five parameters, and the homeowners without children or where the children have moved out can be average or less than average motivated by the same parameters (Fig. 23).

The geographic location of the homeowners and their priority of the five parameters indicate that in order to motivate the homeowners from Copenhagen the five parameters will be more beneficial as motivation than for the three other regions. The respondents from Odense are very similar to the average respondent, whereas those from Aalborg and Aarhus separated themselves from the average by at least one parameter (Fig. 24).

Depending on how long the homeowners have lived in their house, there are different parameters, which can motivate them to conduct energy renovations (Fig. 25). The tendency is clearly that the longer one has lived in the house, the less advantageous the motivation factors are found. The homeowners who have lived in the house for less than five years can be very motivated by all five parameters. After five years, one parameter is average motivating, after 15 years the parameters start to be less than average motivational.

The latest education the homeowners have completed also influences which of the motivation parameters can be said to be realistically useful for each homeowner group (Fig. 26). All of the education groups, except those with a craftsman education, have at least two of the parameters, which are more than average motivating, but the combinations of the parameters vary. For the groups of craftsmen, all five parameters are less than average motivating.

The homeowners' yearly income seems to have an influence on the impact of the five parameters (Fig. 27). Homeowners with a yearly income of more than 750,000 DKK can be very motivated by at least three of the five parameters, whereas the income groups with less than 500,000 DKK a year can generally be motivated less than the average by the listed parameters.

When the respondents are divided by their current occupation, four out of the ten groups have two or more of the

	Kids 0-8 years	Kids 9-13 years	Kids 14-18 years	No kids in the house
Architectural appearance	+	+	+	-
Lay-out	+	+	+	A
Comfort	+	+	+	A
Indoor environment	+	+	+	A
Energy consumption	+	+	+	A

Figure 23. The motivation factors' expected influence on the four groups with different household composition.

	Aalborg	Aarhus	Odense	Copenhagen
Architectural appearance	-	+	A	A
Lay-out	A	A	A	+
Comfort	A	A	A	+
Indoor environment	A	-	A	+
Energy consumption	A	A	A	A

Figure 24. How the influence of the motivation factors presumably will be in the four different regions.

	0-1 year (<5%)	1-5 years	5-10 years	10-15 years	15-20 years	20 - years
Architectural appearance	+	+	+	+	-	-
Lay-out	+	+	A	+	A	A
Comfort	+	+	+	+	+	A
Indoor environment	+	+	+	+	+	-
Energy consumption	+	+	+	A	+	-

Figure 25. The time in which the homeowner have lived in the house and how the parameter can motivate them.

	Primary school	High school (<5%)	Craftsman	Short further education	Long further education	Other
Architectural appearance	+	+	-	+	-	+
Lay-out	-	+	-	A	+	+
Comfort	-	-	-	A	+	A
Indoor environment	+	+	-	+	A	-
Energy consumption	-	+	-	A	A	A

Figure 26. The respondents divided by educational background and the impact of the motivation factors.

	0-199 DKK	200-499 DKK	500-749DKK	750-999 DKK	1,000 DKK and more
Architectural appearance	-	-	+	+	+
Lay-out	-	A	A	A	+
Comfort	-	-	A	+	+
Indoor environment	-	-	A	+	A
Energy consumption	-	-	-	+	-

Figure 27. Respondents divided by the yearly household income in thousands before taxes and how this number relates to the predicted effect of the motivation factors.

motivation factors which are expected to motivate them less than average (Fig. 28). For the group of pensioners, the parameter "lay-out" is the only one that is anticipated to have an average influence. The remaining parameters will have less impact. The homeowners enrolled in education (<5%) or occupied in an academic job are expected to be motivated more than the average homeowner by improvements in all five parameters. The group enrolled in education is, however, less represented in the respondent groups. All groups, except pensioner, can be motivated by architectural appearance.

A variation of parameters have proven to have an impact on the potential motivation factors' effect; age, presence of children, place of residence, time of ownership, education, income and current occupation. In all the analysis differences occur when looking at the subdivisions; some subdivisions can be more than average motivated by all five parameters (for instance those who have lived in their home for less than 5 years (Fig. 25)) and some are harder to motivate than the average homeowner (for example the pensioners (Fig. 28)).

4.4. Which parameters determine the choice of consultants and who are the preferred consultant?

The final aspects studied in this paper are the parameters, which determine who the homeowners will contact for advice in relation to an energy renovation and who their preferred consultant(s) is. The respondents were presented with four different consultants and a "other" category and asked which group they will contact if they need guidance in relation to an energy renovation.

The age divisions show large differences in the use of craftsmen, energy consultants and family/friend for supervision (Fig. 29). Until the age of 69 years the homeowners will preferably contact a craftsman for advice, but after they turn 60 the percentages drop. The homeowners above 70 years favor the energy consultant over the craftsman. Two tendencies are clear in this division: the older the homeowners are, the more of them will seek advice from an energy consultant, and the younger the homeowners are, the more they will ask family/friends and craftsmen for guidance.

Two tendencies are found when the homeowners are divided by the presence and age of children in the household. The younger the children are, the more family and/or friends are used for advice, and the older the children are, the more the energy consultant is used. Especially after the children turn 9 years old, the percentages who will ask the energy consultant increases. The craftsman is, however, the preferred consultant for all four groups.

	Enrolled in education (<5%)	Unskilled worker (<5%)	Semi-skilled worker (<5%)	Skilled worker	Salaried employee	Academic	Self-employed	Receiver of unemployment benefit (<5%)	Pensioner	Other (<5%)
Architectural appearance	+	+	+	+	+	+	+	+	-	+
Lay-out	+	-	-	-	A	+	+	A	A	-
Comfort	+	-	-	-	+	+	+	-	-	+
Indoor environment	+	+	-	+	+	+	+	+	-	+
Energy consumption	+	+	-	+	+	+	-	+	-	+

Figure 28. The respondents divided by their current occupation and how the five motivation factors can affect them.

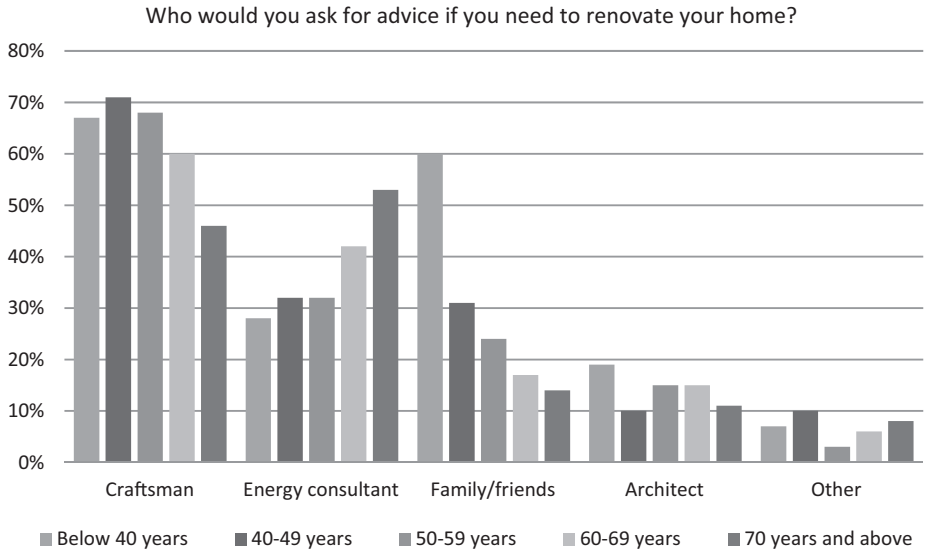

Figure 29. The age of the homeowners in relation to who they will ask for advice about an energy renovation.

The difference is likewise clear when the respondents are divided by place of residence (Fig. 30). Homeowners from Aalborg, Aarhus and Odense prefer to ask the craftsman for advice in relation to an energy renovation whereas the majority of the homeowners from Copenhagen will instead ask an energy consultant to guide them.

How long a homeowner has lived in his house can likewise influence his choice of consultant (Fig. 31). All subgroups have the craftsman as the preferred consultant, but the tendency is, however, that the longer someone has lived in the same house, the more they will use an energy consultant for advice. The architect will mainly be used for advice by the homeowners within their first year in their house. When looking at the use of craftsman and family/friends, the differences are more noteworthy. The craftsman is consulted primarily by the homeowners who have owned their house for more than 1 year and up till 15 years after moving in. After the 15th year, the willingness to contact the craftsman declines. In the first 5 years in the house, the homeowners will ask family and/or friends for advice more than the other groups will.

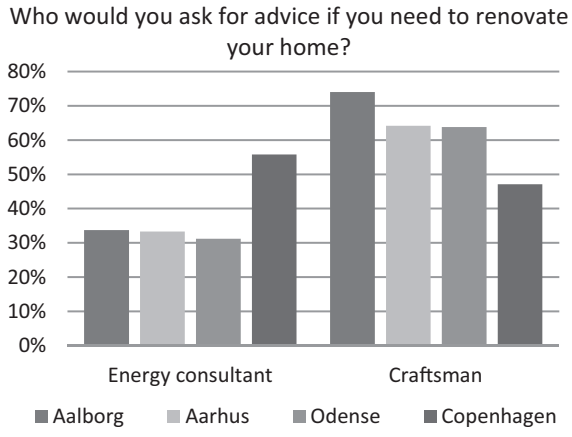

Figure 30. The relationship between the home region of the homeowner and his preferred consultant.

The results indicate that the educational background likewise has an influence on who the homeowners want to ask for advice (Fig. 32). For all six education groups the craftsman is the preferred consultant. The group with the long further education uses the energy consultant more than all others do, and this group does not use the craftsman as much as the other education groups.

The results from the occupation division indicate that this is also a parameter, which affects the consultant(s) choice (Fig. 33). All groups have the craftsman as their preferred consultant, but the second most preferred is the family and/or friends for the homeowners currently enrolled in education (<5%), the skilled workers, salaried employees and those who receive unemployment benefit (<5%). All other groups have the energy consultant as their second choice. Two out of the four groups who have family and/or friends as their second choice of consultant are however represented by less than 5% of the respondents each and therefore the results are only indications of a tendency.

The yearly household income has little influence on the preferred consult, which is the craftsman for all five groups, but when looking at the income in relation to using an architect for consultation, the tendency is clearly that the higher income, the more the homeowners are likely to consult an architect (Fig. 34).

When the homeowner is seeking advice and guidance different parameters affect his choice. His age, the presence of children, place of residence, time of ownership, occupation and income all influence his decision. The majority of the respondents prefer to contact a craftsman, however the subdivisions of homeowners above 70 years of age and

Figure 31. The time lived in the house and how this affect the choice of consultant.

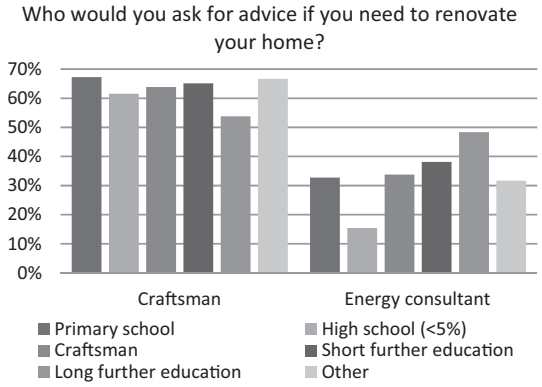

Figure 32. The homeowners' education and the influence it has on their current choice of craftsman and energy consultant as preferred consultant.

those living in Copenhagen have stated that the energy consultant is their preferred advisor.

5. Discussion

The respondents' answers have been analyzed first as one group (the average homeowner) (Mortensen et al., 2014) and second in groups defined by subcategories of eight demographic parameters (gender, age, household composition, place of residence, time of ownership, education, occupation and income). All the demographic parameters influence, to greater or lesser extent, the homeowners' interest in and willingness for energy renovations, the impact level of the motivation factors and the preferred consultant.

The second analysis was carried out by dividing the replies given by a certain group (for instance respondents between the age of 40 and 50 years) and comparing each group's results to both the average replies, from the first analysis, and to the other groups within the same demographic parameter (Fig. 35). The results compared are related to a number of replies given in the questionnaire for instance replies about the current will and interest, future wishes for the house and preferences within comfort, indoor environment and architecture (Fig. 20). Conclusions from these comparisons clarify any differences caused by a demographic parameter.

Three of the demographic variables: gender, place of residence and education have the least impact on the examined areas. When analyzed according to the subdivision within these three variables (for instance women or men), the results reflect the replies given by "the average homeowner". The gender of the homeowner has the least to say on the examined areas, but the results do indicate that the female respondents have more willingness to perform energy renovation (Fig. 14) and can also be more motivated by one of the motivation factors than male respondents can, inter alia since they find the architectural expression more important than men (Fig. 21). Apart from these differences, the genders, in general, agree, and there are no other significant deviations. The respondents are all homeowners (if the ones receiving the letter is also the ones replying) but they will in many cases not be the sole decision maker of the household and the other part, woman or man, should likewise be committed to performing energy renovations if it is to be realistic. Therefore these differences in themselves are not expected to create results, but if one part of the household can be motivated the other part might be influenced from it. The differences between genders, despite few, are pointed out since the information can be beneficial in the future motivation strategy to identify for instance the right media to spread the messages depending on whether the media is aimed at women or men.

The results indicate that the homeowners from Copenhagen can have more interest in energy renovation than the other three regions. This difference can be caused by, among others, the differences in energy prices across the country. The price for energy in the area around Copenhagen is higher than it is around for instance Aalborg (Danish Energy Regulatory Authority). Therefore, the homeowners in Copenhagen have extra economical incentives for taking interest in this compared to those from Aalborg. The Copenhagen homeowner can reduce the size of

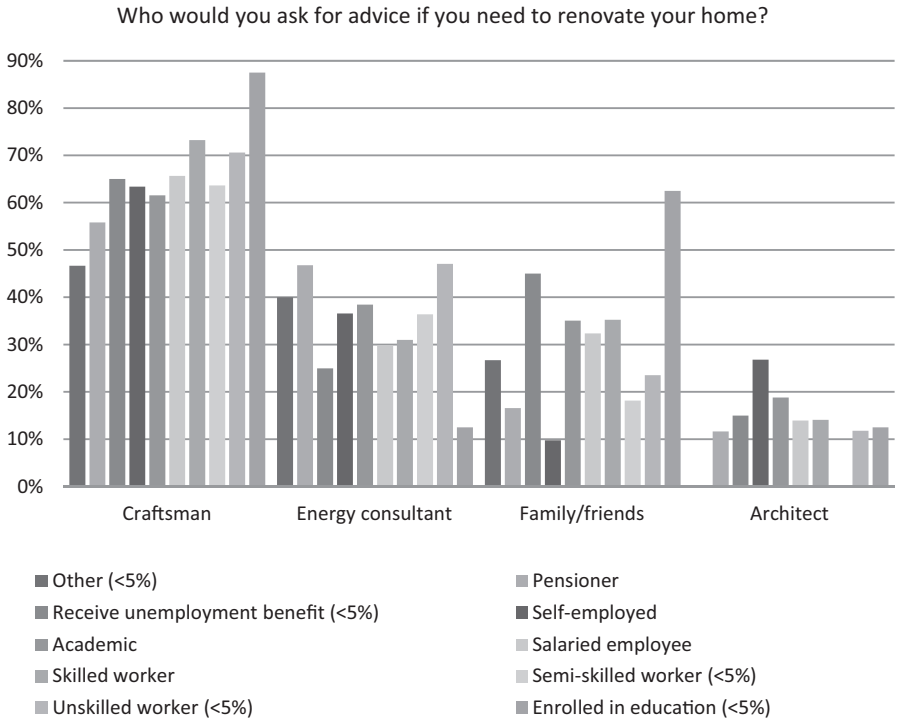

Figure 33. Illustration of the choice of preferred consultant as made by the different occupation groups.

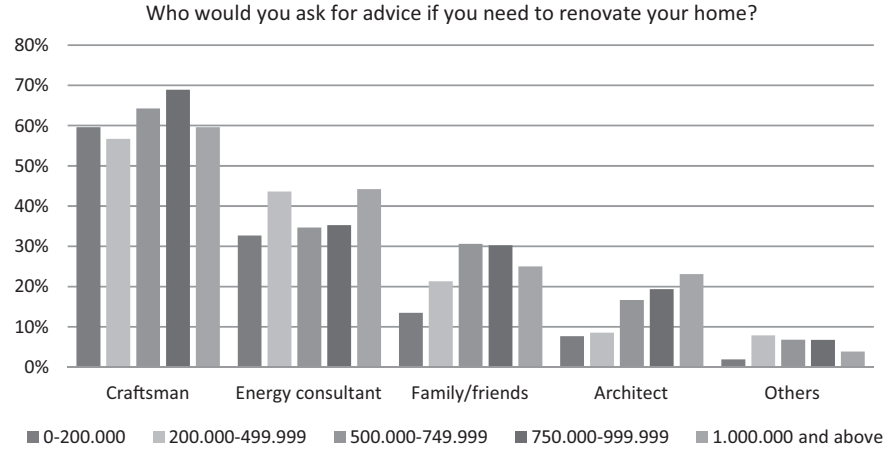

Figure 34. How the yearly household income in DKK affects the choice of preferred consultant.

his energy bill a lot by conducting energy saving renovations whereas the homeowners in Aalborg will not experience the same percentage-wise reduction by similar initiatives. However a lower energy consumption is not more than average motivating for the Copenhagen homeowners (Fig. 24) and therefore the survey results cannot state, if in fact energy prices are causing the higher interest or if other aspects are initiating this difference. The homeowners from Copenhagen once more stand out from the other three regions when asked about their preferred consultant, since they will ask an energy consultant for guidance whereas the other groups will ask a craftsman (Fig. 30). This means that the future motivation strategy in the regions should take into consideration whom the consultant should be in order to get the highest success rate. The educational background of the homeowners has little impact on the interest (Fig. 12), willingness (Fig. 18) and the preferred consultant (Fig. 32). It does, however, influence the expected impact of the motivation factors, where the craftsmen educated homeowners separate themselves by being the group expected to be affected less than average by all five motivation factors (Fig. 26). This again indicates that it is of great importance which of the craftsmen the homeowners get in contact with when they look for advice and consultancy (Section 4.4). If the craftsman

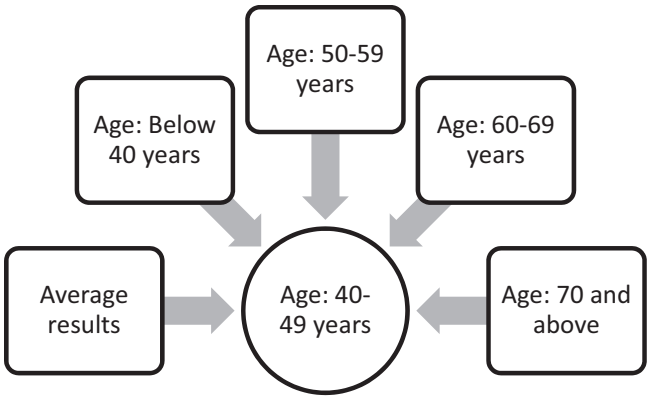

Figure 35. Example of how the analysis result from one subgroup (age 40–49 years) is compared to the results from other groups and to the average results. The example shows the subgroups in the parameter age.

is not particularly motivated by energy renovation himself, he might not be the best motivator for the homeowners.

The craftsmen educated respondents have nevertheless a high level of interest in energy renovation (Fig. 12), which is very positive if they should act as consultants in the future. It is, based on the results, recommended that it is in fact a craftsman who knows about and has a personal interest in energy savings and renovations who covers the task of motivating the homeowners. It is, however, important to point out that the "craftsman education" covers all types of craftsman professions and not only those related to building work.

The demographic variables which have a significant influence on the interest, the will, the motivation impact and the preferred consultant are age, household composition, length of ownership, occupation and income. The results indicate that age could be the pivotal parameter for determination of the homeowners' interest, willingness and motivation level. However, number and age of children, length of ownership, occupation and income are often related to the homeowners' age and vice versa. Meaning that the age is just an indicator of the current place in the life cycle of the homeowner and, therefore, this parameter is just as much the primary influential parameter as the others, since they too can tell something about the current life situation. Where the homeowners are in their life cycle is consequently the most crucial aspect to look at when defining how to motivate a homeowner in the best manner. Overall, the respondents can be classified into two groups. The younger group and the older group. The two groups are significantly different, where the younger group is interested in and has the will to carry out energy renovation, the older group has little or no interest or desire to conduct energy renovations.

A research project about ecological renovation and maintenance of single-family houses from 2001 concluded that when focusing on three parameters of the house (kitchen, windows and water (wastewater/water savings)) three homeowner groups appeared with different interest and willingness; The young families, The middle-aged families and The elderly homeowners (Section 1) (Almlund et al., 2002). Despite many of the characteristics being alike for the younger families and the elderly in the 2001 survey and the study presented in this paper there is in this survey not proven a significant different which justifies a third group of homeowners (the middle-aged families). This can be caused by a variation of aspects. First of all, this survey is not limited to a few smaller selected aspects, but is focusing on energy renovation in general and covering the entire house. This can result in both other levels of interest and will and other needed motivation factors. The focus of the two surveys also differs since the first survey had its focus on the environmental impacts whereas this survey focused on the motivation for private energy renovations. Secondly the questions were not asked in the same way in the two surveys, primarily due to the variations in the survey objectives but also since the researchers in the two surveys were not the same. Depending on the way and order of the questions, the answers naturally differ. The two surveys had different objectives, despite similar theme, which naturally have affected the question structure and consequently the replies given cannot be expected to be similar. Another not to be neglected difference is that the 2001 study contained responses from 70 questionnaires and 9 interviews with homeowners, whereas this study did not consist of the mix, but instead had approximately 900 completed questionnaires as basis for the analysis. The larger amount of replies ought to give a more valid picture of the respondents, but the other variations can also be the reason for the different conclusions. Finally the aspect of time can be a significant parameter. From the first study carried out in 1999–2001. 11 years have passed before this study was conducted in 2012. In these years a lot has changed in the field of renovation and sustainability and in particular in the private economy of the homeowners, which can influence the interest and will in conducting energy saving renovation severely. The two homeowner groups defined in this project; the younger and the older generation reflects in numerous cases the young families and the elderly homeowners of the previous study (Almlund).

The younger generation (under the age of 50 years) who has the highest interest in energy renovations (Fig. 9) also has the highest willingness to perform energy renovations (Fig. 15). There is, however, a potential drawback to these positive numbers; this group is besides the group where most respondents state that they do not want a higher monthly house expense (Fig. 15). This indicates that even though the interest and willingness are present the economy of a possible project should be balanced by the energy savings in order to be realistic. Otherwise it can be difficult to motivate this group of homeowners, despite the expected positive influence by the motivation factors (Fig. 22).

The results clearly show that the older generation above the age of 60 years or maybe even from 50 years old and up have less interest in renovation (Fig. 9) and less willingness to conduct renovation (Fig. 15), and the motivation factors

have less impact here (Fig. 22) than on the younger generation.

There is a 7811 TJ/year energy saving potential found in the single-family houses from the 1960s and 70s if they are renovated to a level comparable with the present level of new buildings (Wittchen, 2009). If the homeowners above the age of 60 years, which correspond to 41% of all residents in these type of buildings (Statistics Denmark, BOL201), cannot be motivated to perform energy renovations, the potential drops to 4608 TJ/year. If all homeowners above 50 years, which is 60% of all residents (Statistics Denmark, BOL201), prove impossible to motivate, the potential will be only 3124 TJ/year. The older generation accounts for a very large part of the homeowners in this building type, and this means that even though it might be harder to motivate the older generation, it is crucial to make an effort. There are some homeowners in the older generation who have both interest, willingness and can be motivated, and this opportunity should naturally be exploited to the full.

It is clear from the analysis results that the interest (Fig. 11), willingness (Fig. 17) and impact from the motivation factors (Fig. 25) decrease with the time in which the homeowners have lived in the house. This and the fact that homeowners tend to stay for numerous years in the same house imply that if the energy saving goals for 2020 and 2050 (European Commission, 2011; Official Journal of the European Union, 2012) are to be reached, it is important to get in contact with the homeowners in the first years after purchase. If the current homeowner generation stays for as long as the earlier, there will only be one or maybe two chances to get in contact with new homeowners before 2050, meaning that the strategy should be developed as soon as possible, as there is no room for failure if the goals should still be realistic.

To ensure future increase in the private energy renovation rate it is recommended that the craftsmen, and possibly also the energy consultants, undergo further training since the results show that these professionals are the homeowners preferred advisor in relation to an energy renovation (Section 4.4). For the future success in motivating homeowners, it is important that the consultant, independent of his profession, has an updated knowledge of the present energy saving initiatives and opportunities, and that he (can) suggests and recommends energy savings as part of other renovation/building projects. Therefore, it is suggested that the education provides him with tools about the financial side of renovation projects (cost and savings) and knowledge about the benefits, which the homeowners can expect from the different initiatives related to architecture, indoor environment and comfort. These are all aspects, which are crucial in the motivation process. The authors find that the craftsman's role in the future ideally should change from being the traditional performing part of a project to likewise being the professional consultant who can in fact motivate the homeowners.

In the future, there are two ways to address the area of energy renovations in order to increase the number of private energy renovation projects. One way is to focus on the average of the homeowners and make campaigns, which aim broadly and reach everybody (Mortensen et al., 2014). This should be campaigns where all improvements from an energy renovation are presented and explained, covering all five motivation factors (Mortensen et al., 2014). The other way to go, is by dividing the homeowners into groups according to their life cycle or even more specific divisions such as residential area, age of children or occupation. Then the campaigns can be targeted toward the specific group, and the information gathered in this study used as the basis for the design of the material. Among others must the material developer consider if the homeowners already have an interest in energy renovations on which the new information can build on or if they have some wishes for their house, which can be used as a basis for the motivation work. The objective of this approach is to be focused on, acknowledge and exploit the different starting points found among homeowners. With a specific effort, the homeowner will presumably feel more motivated since he gets only the information he lacks, demands and needs (knowingly or unknowingly). This is trusted to be a beneficial approach since one of the most substantial barriers for energy renovation is lacking knowledge about the subject and the opportunities (The Danish knowledge centre for energy savings in buildings, 2009; Jensen, 2004, 2009). For instance can the right information, delivered by the right consultant, possibly open the eyes of a homeowner, make him see potential problems in his house, which he had not acknowledged himself and motivate him by improvements in for example comfort and indoor environment.

6. Conclusion

From the results presented, it is clear that the homeowners are not one homogeneous group where everybody thinks and acts alike. Neither can the same improvements, motivation factors and consultants motivate the homeowners. Their interest and willingness to perform energy renovations furthermore varies a lot depending on their demographic background.

There are significant differences found among the groups, depending on the demographic parameters. Not one of the eight parameters (age, gender, presence and age of children, time in the house, place of residence, education, occupation and income) is the predominating one, but the tendency is that the differences found can mainly be related to the homeowner's current place in life; a combination of age, presence and age of children, the time in which he has owned the house, occupation and income. The gender, place of residence and education have little to do with the identified differences.

The homeowners can, generally speaking, be divided into two groups who have different interest in and willing-

ness to perform energy renovations and who are expected to be affected differently by the motivation factors and consultants: The younger generation (broadly speaking under the age of 50) and the older generation (broadly speaking above 50 years of age). A number of subdivisions can also be beneficial for the future motivation strategies, however the replies from the two groups clearly separate themselves from each other when analyzing the data.

The younger homeowners, who in many cases have children, have lived for at shorter period of time in their house and have a high income are more interested in and willing to conduct energy renovation. This group is furthermore motivated by all five motivation factors: Improvements in Architectural appearance, Lay-out, Comfort, Indoor environment and Energy consumption and should preferably be motivated by a craftsman.

Homeowners in the older generation, who might have been part of the building process in the 1960s or 1970s, have lived in the house for a longer period of time, are living in the house without children, are retired and have a relatively low income, will be harder to motivate due to their lacking interest, willingness and their evaluation of the house related parameters as being in good condition. There are, nevertheless, motivation factors, which can be effective among this generation, and hence it is still possible to motivate these homeowners (Fig. 22). Improvements in the lay-out and comfort of the houses are expected to motivate this generation and the consultant to inform them about these benefits and increase the interest in energy renovations should be either a skilled craftsman or an energy consultant (Fig. 29). Furthermore is a positive project economy extremely important to emphasize when motivating this group of homeowners since they have some will to conduct the energy renovations as long as they do not get a higher monthly expense. The job of motivating this generation must, despite the extra effort required, be carried out in order to utilize as much of the total energy saving potential as possible.

These conclusions suggest that a more varying approach to the process of increasing the amount of private energy renovation projects is the most beneficial. The future motivation campaigns should be directed at a specific target group and subsequently be designed with variations. Naturally, this will require more resources than current strategies, where a broader approach is executed, since more preparatory work and detailed design of different campaigns will be needed. However, results indicate that the resources will be well spent since the differences between the groups are significant and hence a focused approach will be most effective and generate more success in the end.

At least two target groups should be defined; a younger and an older generation and the campaigns must revolve around these. For the younger group this includes jobs, children and a long future in the house and for the older generation a peaceful retirement age might be in sight, but not many years in the same house. The two life situations should be handled differently and a motivation campaign for the older generation should put into play completely different aspects than for the younger generation, even if both campaigns are generating motivation on the basis of, for example, improved comfort. What an important comfort improvement is for a family with small children might not be the same for two pensioners. Additional subdivisions of the homeowners can be further advantageous for a more rapid progress but will naturally require even more resources.

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